AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

LISTING OF CLAIMS:

1. (original): A sensorless vector control method for an alternating-current motor,

the sensorless vector control method employing:

a power converter, for outputting arbitrary power to the alternating-current motor,

a current detection circuit, for detecting a current supplied to the alternating-current motor,

a coordinate conversion circuit, for converting the current supplied to the alternating-current motor into an exciting current detection value and a torque current detection value and for outputting thereof,

an exciting current control circuit, for controlling an exciting current directional voltage so as to match the exciting current instruction value with the exciting current detection value,

a torque current control circuit, for controlling a torque current directional voltage so as to match the toque current instruction value with the torque current detection value,

a V/f conversion circuit, for calculating an induction voltage for the alternating-current motor based on a given output frequency instruction,

a phase angle operation circuit, for obtaining a phase angle by integrating the given output frequency instruction, and

an output voltage operation circuit, for calculating a level and a phase for an output voltage based on voltage instructions that are output by the exciting current control circuit, the torque current control circuit and the V/f conversion circuit, wherein

a velocity detector and a voltage detector are not provided,

a phase angle, output by the phase angle operation circuit, is added to the level and the phase output by the output voltage operation circuit in order to regulate the switching of the power converter,

the sensorless vector control method comprising the steps of:

applying a direct current or a direct-current voltage to the alternating-current motor in a free running state before the alternating-current motor is started,

estimating a rotational direction and a velocity for the alternating-current motor based on a secondary current that flows at the application time,

setting a frequency that corresponds to the rotational direction and the velocity for a frequency adjustment circuit to activate the alternating-current motor,

matching the frequency adjustment circuit an output frequency with the velocity of the alternating-current motor, and

estimating, based on the level of a current flowing in the alternating-current motor, that the rotational direction and the frequency designated for the frequency adjustment circuit deviate from the actual rotational direction and the actual velocity of the alternating-current motor.

2. (original): The sensorless vector control method for an alternating-current motor, according to claim 1, wherein

a case that the level of the current flowing in the alternating-current motor is continued for a designated period of time, at an equal to or higher than designated current level, is established as a reference that is used to estimate that the rotational direction and the frequency designated for the frequency adjustment circuit deviate from the actual rotational direction and the actual velocity of the alternating-current motor.

3. (currently amended): The sensorless vector control method for an alternating-current motor, according to claim 1 ~~or 2~~, wherein

after it is estimated that the rotational direction and the frequency designated to the frequency adjustment circuit deviate from the actual rotational direction and the actual velocity of the alternating-current motor,

a restarting of the alternating-current motor is halted,

a direct current or a direct-current voltage is applied to the alternating-current motor,

a secondary current, flowing at the application time, is employed to reevaluate the rotational direction and the velocity of the alternating-current motor,

a frequency that corresponds to the rotational direction and the velocity is again set to the frequency adjustment circuit, and

the alternating-current motor is restarted.

4. (original): The sensorless vector control method for an alternating-current motor, according to claim 3, wherein

when a direct current or a direct-current voltage is applied to the alternating-current motor, and a secondary current flowing at the application time is employed to reevaluate the rotational direction and the velocity of the alternating-current motor,

the velocity is estimated that the upper limit value for an estimated value is lower by a designated velocity value than the velocity is previously estimated to be, or is equal to the final output value of the frequency adjustment circuit,

a frequency that corresponds to the estimated value is set to the frequency adjustment circuit, and

the alternating-current motor is started.

5. (original): A sensorless vector control apparatus, for an alternating-current motor, comprising:

a power converter, for outputting arbitrary power to the alternating-current motor,

a current detection circuit, for detecting a current supplied to the alternating-current motor,

a coordinate conversion circuit, for converting the current supplied to the alternating-current motor into an exciting current detection value and a torque current detection value and for outputting thereof,

an exciting current control circuit, for controlling an exciting current directional voltage so as to match the exciting current instruction value with the exciting current detection value,

a torque current control circuit, for controlling a torque current directional voltage so as to match the toque current instruction value with the torque current detection value,

a V/f conversion circuit, for calculating an induction voltage for the alternating-current motor based on a given output frequency instruction,

a phase angle operation circuit, for obtaining a phase angle by integrating the given output frequency instruction, and

an output voltage operation circuit, for calculating a level and a phase for an output voltage based on voltage instructions that are output by the exciting current control circuit, the torque current control circuit and the V/f conversion circuit, wherein

a phase angle, output by the phase angle operation circuit, is added to the level and the phase output by the output voltage operation circuit in order to regulate the switching of the power converter,

a velocity detector and a voltage detector are not provided, and

a direct current or a direct-current voltage is applied to the alternating-current motor in a free running state before the alternating-current motor is started, a rotational direction and a velocity for the alternating-current motor are estimated based on a secondary current that flows at the application time, a frequency that corresponds to the rotational direction and the velocity are set for a frequency adjustment circuit to activate the alternating-current motor, and the frequency adjustment circuit matches an output frequency with the velocity of the alternating-current motor,

the sensorless vector control apparatus, further comprising:

erroneous setup estimation member for estimating, based on the level of a current flowing in the alternating-current motor, that the rotational direction and the frequency designated for the frequency adjustment circuit deviate from the actual rotational direction and the actual velocity of the alternating-current motor.

6. (original): The sensorless vector control apparatus for an alternating-current motor, according to claim 5, wherein

a case that the level of the current flowing in the alternating-current motor is continued for a designated period of time, at an equal to or higher than designated current level, is established as a reference that is used by the erroneous setup estimation member to estimate that the rotational direction and the frequency designated for the frequency adjustment circuit deviate from the actual rotational direction and the actual velocity of the alternating-current motor.

7. (currently amended): The sensorless vector control apparatus for an alternating-current motor, according to claim 5 ~~or 6~~, wherein

after the erroneous setup estimation member estimates a setup is incorrect,

a restarting of the alternating-current motor is halted,

a direct current or a direct-current voltage is again applied to the alternating-current motor,

a secondary current, flowing at the application time, is employed to reevaluate, the rotational direction and the velocity of the alternating-current motor,

a frequency that corresponds to the rotational direction and the velocity is again set to the frequency adjustment circuit, and

the alternating-current motor is restarted.

8. (original): The sensorless vector control method for an alternating-current motor, according to claim 7, wherein

when a direct current or a direct-current voltage is applied to the alternating-current motor, and a secondary current flowing at the application time is employed to reevaluate the rotational direction and the velocity of the alternating-current motor,

while estimating the velocity is such that the upper limit value for an estimated value is lower by a designated velocity value than the velocity is previously estimated to be, or is equal to the final output value of the frequency adjustment circuit, and

a frequency that corresponds to the estimated value and starting the alternating-current motor is set for the frequency adjustment circuit.

9. (original): A sensorless vector control method for an alternating-current motor,

the sensorless vector control method employing:

a power converter, for outputting arbitrary power to the alternating-current motor,

a current detection circuit, for detecting a current supplied to the alternating-current motor,

a coordinate conversion circuit, for converting the current supplied to the alternating-current motor into an exciting current detection value and a torque current detection value and for outputting thereof,

an exciting current control circuit, for controlling an exciting current directional voltage so as to match the exciting current instruction value with the exciting current detection value,

a torque current control circuit, for controlling a torque current directional voltage so as to match the toque current instruction value with the torque current detection value,

a V/f conversion circuit, for calculating an induction voltage for the alternating-current motor based on a given output frequency instruction,

a phase angle operation circuit, for obtaining a phase angle by integrating the given output frequency instruction, and

an output voltage operation circuit, for calculating a level and a phase for an output voltage based on voltage instructions that are output by the exciting current control circuit, the torque current control circuit and the V/f conversion circuit, wherein

a phase angle, output by the phase angle operation circuit, is added to the level and the phase output by the output voltage operation circuit in order to regulate the switching of the power converter,

a velocity detector and a voltage detector are not provided,

the sensorless vector control method comprising the steps of:

applying a direct current or a direct-current voltage to the alternating-current motor in a free running state for a set time before the alternating-current motor is started,

estimating a rotational direction and a velocity for the alternating-current motor based on a secondary current that flows at the application time,

setting a frequency that corresponds to the rotational direction and the velocity for a frequency adjustment circuit to activate the alternating-current motor, and

matching the frequency adjustment circuit an output frequency with the velocity of the alternating-current motor, and

setting, as a period of time for applying a direct current or a direct-current voltage, a greater value, either an estimated lower limit value for the alternating-current motor, or a value obtained based on a value designated as a secondary circuit time constant.

10. (original): The sensorless vector control method for an alternating-current motor, according to claim 9, wherein

when the frequency of a secondary current is not obtained during the period in which the direct current or the direct-current voltage is being applied,

it is determined that the alternating-current motor is halted, and

a predesignated lowest frequency or a zero frequency is transmitted to the frequency adjustment circuit.

11. (original): A sensorless vector control apparatus, for an alternating-current motor, comprising:

a power converter, for outputting arbitrary power to the alternating-current motor,

a current detection circuit, for detecting a current supplied to the alternating-current motor,

a coordinate conversion circuit, for converting the current supplied to the alternating-current motor into an exciting current detection value and a torque current detection value and for outputting thereof,

an exciting current control circuit, for controlling an exciting current directional voltage so as to match the exciting current instruction value with the exciting current detection value,

a torque current control circuit, for controlling a torque current directional voltage so as to match the toque current instruction value with the torque current detection value,

a V/f conversion circuit, for calculating an induction voltage for the alternating-current motor based on a given output frequency instruction,

a phase angle operation circuit, for obtaining a phase angle by integrating the given output frequency instruction, and

an output voltage operation circuit, for calculating a level and a phase for an output voltage based on voltage instructions that are output by the exciting current control circuit, the torque current control circuit and the V/f conversion circuit, wherein

a phase angle, output by the phase angle operation circuit, is added to the level and the phase output by the output voltage

operation circuit in order to regulate the switching of the power converter,

a velocity detector and a voltage detector are not provided,

a direct current or a direct-current voltage is applied to the alternating-current motor in a free running state for a set time before the alternating-current motor is started,

a rotational direction and a velocity for the alternating-current motor are estimated based on a secondary current that flows at the application time,

a frequency that corresponds to the rotational direction and the velocity are set for a frequency adjustment circuit to activate the alternating-current motor,

the frequency adjustment circuit matches an output frequency with the velocity of the alternating-current motor, and

a greater value, either an estimated lower limit value for the alternating-current motor, or a value obtained based on a value designated as a secondary circuit time constant is set as a period of time for applying a direct current or a direct-current voltage.

12. (original): The sensorless vector control apparatus for an alternating-current motor, according to claim 11, wherein

when the frequency of a secondary current is not obtained during the period in which the direct current or the direct-current voltage is being applied,

it is determined that the alternating-current motor is halted, and

a predesignated lowest frequency or a zero frequency is transmitted to the frequency adjustment circuit.

13. (original): A sensorless vector control method for an alternating-current motor,

the sensorless vector control method employing:

a power converter, for outputting power to an alternating-current motor, and

a current controller, for controlling a current output by the power converter based on a signal indicating a deviation between a current instruction signal and a detection signal for a current output by the power converter, wherein

a velocity detector and a voltage detector are not provided,

the sensorless vector control method comprising the steps of:

effecting current control by forcibly setting the current instruction signal to zero so as to reduce to zero a current in the alternating-current motor in a free running state,

calculating a level and a phase of a residual voltage in the alternating-current motor, and an angular velocity, based on an output voltage instruction signal obtained by employing a current output by the current controller,

estimating a rotational direction and velocity of the alternating-current motor in the free running state, and

determining a wait time until the current control is started with the current instruction signal value set to zero in accordance with a run-time frequency of the power converter before the free running state and a secondary circuit time constant of the alternating-current motor.

14. (original): The sensorless vector control method for an alternating-current motor, according to claim 13, wherein

when the run-time frequency of the power converter before the free running state is entered is lower than an arbitrarily designated frequency,

the wait time until the current control is started with the current instruction signal value of zero is set to zero.

15. (currently amended): The sensorless vector control method for an alternating-current motor, according to claim 13 ~~or 14~~, wherein

when an induction voltage of the alternating-current motor is so high that it is difficult to adjust a current in the alternating-current motor to zero,

the control for setting the current in the alternating-current motor to zero is halted,

an arbitrarily provided time-power converter is permitted to prepare switching so as to short-circuit three phases of an input to the alternating-current motor,

a damping force on the alternating-current motor is exerted,

the alternating-current motor is decelerated,

the current of the alternating-current motor is controlled again to zero, and

the rotational direction and the velocity of the alternating-current motor in the free running state are estimated.

16. (original): A sensorless vector control apparatus for an alternating-current motor, comprising:

a power converter, for outputting power to an alternating-current motor, and

a current controller, for controlling a current output by the power converter based on a signal indicating a deviation between a current instruction signal and a detection signal for a current output by the power converter, wherein

a velocity detector and a voltage detector are not provided,

current control is effected by forcibly setting the current instruction signal to zero so as to reduce to zero a current in the alternating-current motor in a free running state, and

a level and a phase of a residual voltage in the alternating-current motor, and an angular velocity, are calculated based on an output voltage instruction signal obtained by employing a current output by the current controller,

a rotational direction and velocity of the alternating-current motor in the free running state are estimated, and

a wait time until the current control is started with the current instruction signal value set to zero is determined in accordance with a run-time frequency of the power converter before the free running state and a secondary circuit time constant of the alternating-current motor.

17. (original): The sensorless vector control apparatus for an alternating-current motor, according to claim 16, wherein

when the run-time frequency of the power converter before the free running state is entered is lower than an arbitrarily designated frequency,

the wait time until the current control is started with the current instruction signal value set to zero is set.

18. (currently amended): The sensorless vector control apparatus for an alternating-current motor, according to claim 16 ~~or 17~~, wherein

when an induction voltage of the alternating-current motor is so high that it is difficult to adjust a current in the alternating-current motor to zero,

the control for setting the current in the alternating-current motor to zero is halted,

an arbitrarily provided time-power converter is permitted to prepare switching so as to short-circuit three phases of an input to the alternating-current motor,

a damping force on the alternating-current motor is exerted,

the alternating-current motor is decelerated,

the current of the alternating-current motor is controlled again to zero, and

the rotational direction and the velocity of the alternating-current motor in the free running state is estimated.

19. (original): A sensorless vector control method for an alternating-current motor, employing:

a power converter, for outputting power to the alternating-current motor, and

a current controller, for controlling a current output by the power converter based on a signal indicating a deviation between a current instruction signal and a detection signal for a current output by the power converter, wherein

both a velocity detector and a voltage detector are not provided,

the sensorless vector control method comprising the steps of:

performing a current control by forcibly setting the current instruction signal to zero so as to reduce to zero a current in the alternating-current motor in a free running state, and

calculating a level and a phase of a residual voltage in the alternating-current motor and an angular velocity based on an output voltage instruction signal obtained by employing a current output by the current controller, and

estimating a rotational direction and a velocity of the alternating-current motor in the free running state,

the sensorless vector control method further comprising the step of:

when a process for reducing to zero the current in the alternating-current motor is to be preformed,

reducing a scanning period for a current control process to less than that for a normal control process.

20. (original): The sensorless vector control method for an alternating-current motor, according to claim 19, wherein

when the process for reducing to zero the current in the alternating-current motor is to be preformed,

the scanning period for the current control process is reduced to less than that for the normal control process, as well as a carrier frequency of the power converter is increased.

21. (original): A sensorless vector control apparatus for an alternating-current motor, comprising:

a power converter, for outputting power to an alternating-current motor, and

a current controller, for controlling a current output by the power converter based on a signal indicating a deviation between a current instruction signal and a detection signal for a current output by the power converter, wherein

a current control is performed by forcibly setting the current instruction signal to zero so as to reduce to zero a current in the alternating-current motor in a free running state,

a level and a phase of a residual voltage in the alternating-current motor and an angular velocity are calculated based on an output voltage instruction signal obtained by employing a current output by the current controller, and then,

a rotational direction and a velocity of the alternating-current motor in the free running state are estimated, and

both a velocity detector and a voltage detector are not provided,

the sensorless vector control apparatus further comprising:

member for, when a process for reducing to zero the current in the alternating-current motor is to be preformed, reducing a scanning period for a current control process to less than that for a normal control process.

22. (original): The sensorless vector control apparatus for an alternating-current motor, according to claim 21, further comprising:

member for, when the process for reducing to zero the current in the alternating-current motor is to be preformed, reducing the scanning period for the current control process to less than that for the normal control process, as well as increasing a carrier frequency of the power converter.

23. (original): A sensorless vector control method for an alternating-current motor,

the sensorless vector control method employing:

a power converter, for outputting power to an alternating-current motor, and

a current controller, for controlling a current output by the power converter based on a signal indicating a deviation between a current instruction signal and a detection signal for a current output by the power converter,

the sensorless vector control method comprising the steps of:

effecting current control by forcibly setting the current instruction signal to zero so as to reduce to zero a current in the alternating-current motor in a free running state,

when the current instruction signal, which is calculated by using a current output by the current controller, is lower than an arbitrarily designated voltage level,

halting current control,

transmitting a direct current instruction at an arbitrary level for a designated period of time,

thereafter transmitting a current instruction at an arbitrary level in a direction with a phase 180° different from the direction in which the direct-current voltage is transmitted, and

performing the current control again during a designated period of time, wherein

a velocity estimation circuit detects a frequency component that appears in a current detection value and a phase relationship thereof, estimates the frequency component as a velocity of the alternating-current motor, and employs the phase relationship to estimate a rotational direction of the alternating-current motor

both a velocity detector and a voltage detector are not provided,

the sensorless vector control method further comprising the step of:

when the velocity and the rotational direction of the alternating-current motor are estimated by providing a direct current instruction for the alternating-current motor,

reducing a scanning time period for a current control process to less than that for a normal control process.

24. (original): The sensorless vector control method for an alternating-current motor, according to claim 23, further comprising the steps of:

when the velocity and the rotational direction of the alternating-current motor are estimated by providing a direct current instruction for the alternating-current motor,

reducing a scanning period of time for a current control process to less than that for a normal control process, as well as increasing a carrier frequency of the power converter.

25. (currently amended): The sensorless vector control method for an alternating-current motor, according to claim 23 ~~or 24~~, further comprising the steps of:

when the velocity and the rotational direction of the alternating-current motor are estimated by providing a direct current instruction for the alternating-current motor,

reducing a scanning period of time for a current control process to less than that for a normal control process, as well as employing a current detector that is different from that used for the normal control process and that is so sensitive a small current is detected.

26. (original): A sensorless vector control apparatus for an alternating-current motor, comprising:

a power converter, for outputting power to an alternating-current motor, and

a current controller, for controlling a current output by the power converter based on a signal indicating a deviation between a current instruction signal and a detection signal for a current output by the power converter, wherein

both a velocity detector and a voltage detector are not provided,

current control is effected by forcibly setting the current instruction signal to zero so as to reduce to zero a current in the alternating-current motor in a free running state,

when the output voltage instruction signal, which is calculated by using a current output by the current controller at this time, is lower than an arbitrarily designated voltage level, current control is halted, and a direct current instruction is transmitted at an arbitrary level in an arbitrary direction for a designated period of time,

thereafter, a current instruction is transmitted at an arbitrary level in a direction with a phase 180° different from the direction in which the direct-current voltage is transmitted, and the current control is performed again during a designated period of time, and

a velocity estimation circuit detects a frequency component that appears in a current detection value and a phase relationship thereof, estimates the frequency component as a velocity of the alternating-current motor, and employs the phase relationship to estimate a rotational direction of the alternating-current motor,

the sensorless vector control apparatus further comprising:

member for reducing a scanning time period for a current control process to less than that for a normal control process, when the velocity and the rotational direction of the alternating-current motor are estimated by providing a direct current instruction for the alternating-current motor.

27. (original): The sensorless vector control apparatus for an alternating-current motor, according to claim 26, further comprising:

when the velocity and the rotational direction of the alternating-current motor are estimated by providing a direct current instruction for the alternating-current motor,

member for reducing a scanning period of time for a current control process to less than that for a normal control process, as well as increasing a carrier frequency of the power converter.

28. (currently amended): The sensorless vector control method for an alternating-current motor, according to claim 26 ~~or 27~~, further comprising:

when the velocity and the rotational direction of the alternating-current motor are estimated by providing a direct current instruction for the alternating-current motor,

a current detector for reducing a scanning period of time for a current control process to less than that for a normal control process, as well as employing a current detector that is different from that used for the normal control process and that is so sensitive a small current is detected.

AMENDMENTS TO THE DRAWINGS:

In the set of drawings, drawing sheet 9/10 is, erroneously, labeled as Fig. 10 instead of Fig. 9. Thus, drawing sheet 9/10 of the set of drawings is amended to read as Fig. 9, as indicated in the enclosed marked-up drawing.

Attachment: Annotated Marked-Up Drawing (Fig. 9)
Replacement Sheet (Fig. 9)